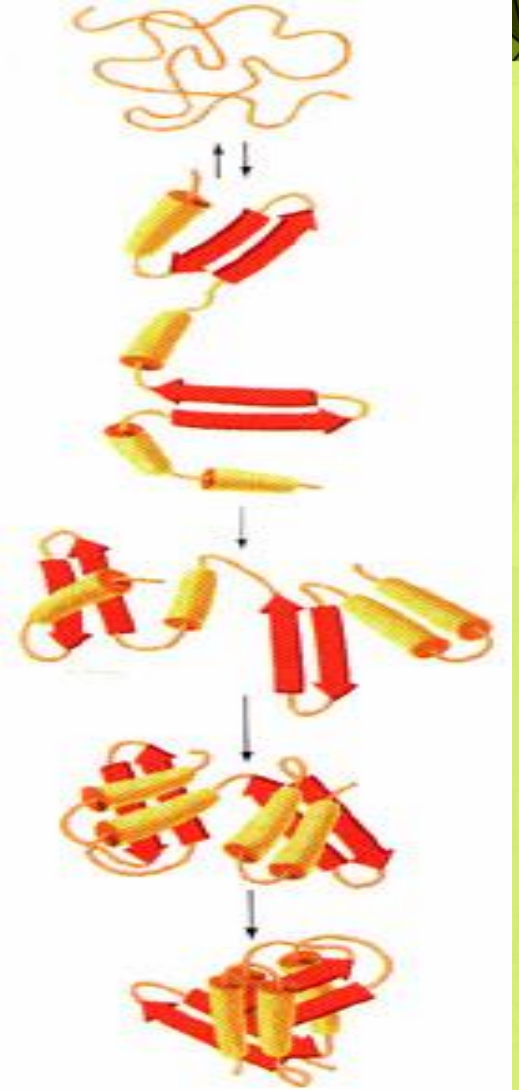


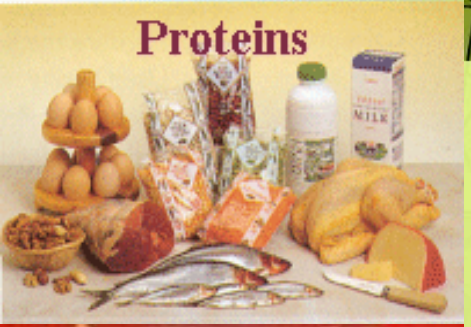
Kimia Pangan

Protein




Materi Kuliah

Pokok Bahasan	TIK	Sub Pokok bahasan
Protein	Mahasiswa mampu menjelaskan struktur serta fungsi asam amino dan protein, termasuk enzim	• **Struktur kimia asam amino dan protein** • **Sifat fisikokimia asam amino dan protein** • **Klasifikasi protein** • **Denaturasi protein** • **Sifat fungsional protein** • Enzim (tatanama dan spesifisitas enzim)





Protein

- Makromolekul (polipeptida) yang tersusun dari asam amino yang dihubungkan satu sama lain dengan ikatan peptida.
- Sumber:
  - Nabati (kedelai, kacang-kacangan, dsb)
  - Hewani (daging, ikan, unggas, dsb)
- Merupakan molekul yang besar, mengandung lebih dari 100 residu asam amino.
- Jenis: globular, fibrous, conjugated

Protein

Fungsi bagi tubuh:

- Pengatur
- Pembangun
- Aktivitas biologis (hormon, enzim dll)

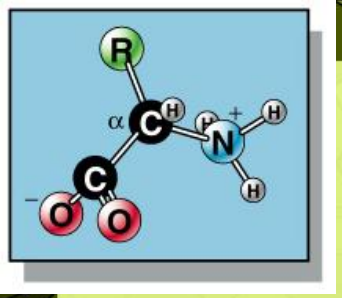
1 g/kg BB/hari

Protein Function

Enzymes	Catalytic activity A → B
Transport Proteins	Bind & carry ligand molecules (hemoglobins)
Storage Proteins	Ovalbumin, ferretin, casein
Contractile Proteins	Can contract, change shape (actin & myosins) make up elements of cytoskeleton & muscles
Structural Proteins	Provide support: collagen fibers of tendons, elastin of ligaments, keratin of hair & feathers, fibroin of silk & spider webs
Defensive Proteins	Provide protection: antibodies (IgG), fibrinogen, thrombin, and snake venoms
Regulatory Proteins	Regulate metabolic processes: includes hormones, transcription factors & enhancers

Protein Content in Foods

Animal origin	Protein (%)	Plant origin	Protein (%)
Milk		Rice, whole	7.5-9.0
Whole, dried	22-25	Rice, polished	5.2-7.6
Skimmed, dried	34-38	Wheat, flour	9.8-13.5
Beef		Corn meal	7.0-9.4
Dried	81-90	Potato	10-13
Roasted	72	Soybean	33-42
Egg		Peanut	25-28
Whole, dried	35	Tapioca	1.3
Whole, dried, defatted	77	Chickpea	22-28

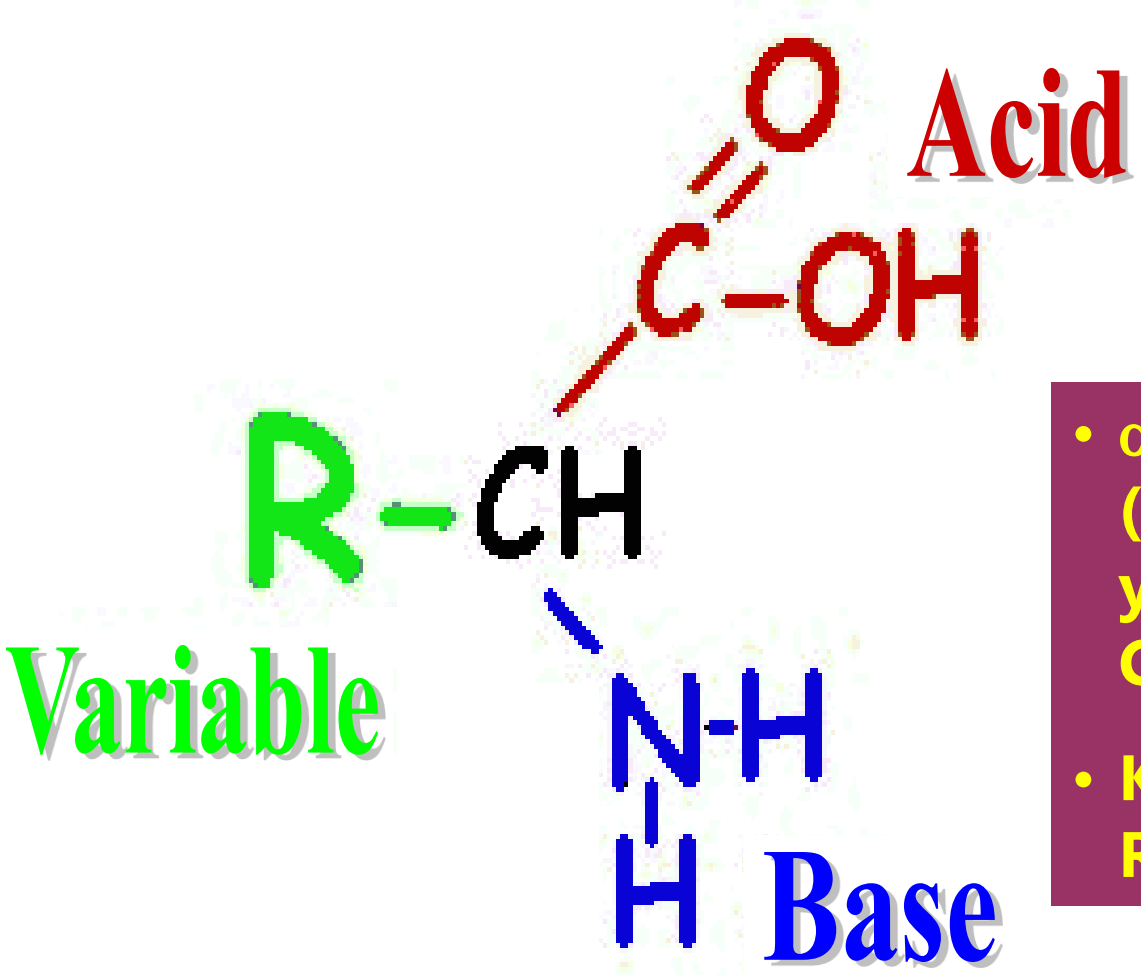


Asam amino

- Senyawa organik yang mengandung 2 gugus fungsional:
  - Amin ($-NH_2$): Bersifat basa
  - Karboksil (-COOH): Bersifat asam
- Kedua gugus fungsional tersebut terikat pada karbon (α-karbon)
- α-C bersifat asimetrik (kecuali glisin): bersifat optik aktif
- Struktur dapat dinyatakan sebagai **struktur ion dipolar.**
- Bersifat amfoterik: dapat berperilaku sebagai asam atau basa.

Asam Amino

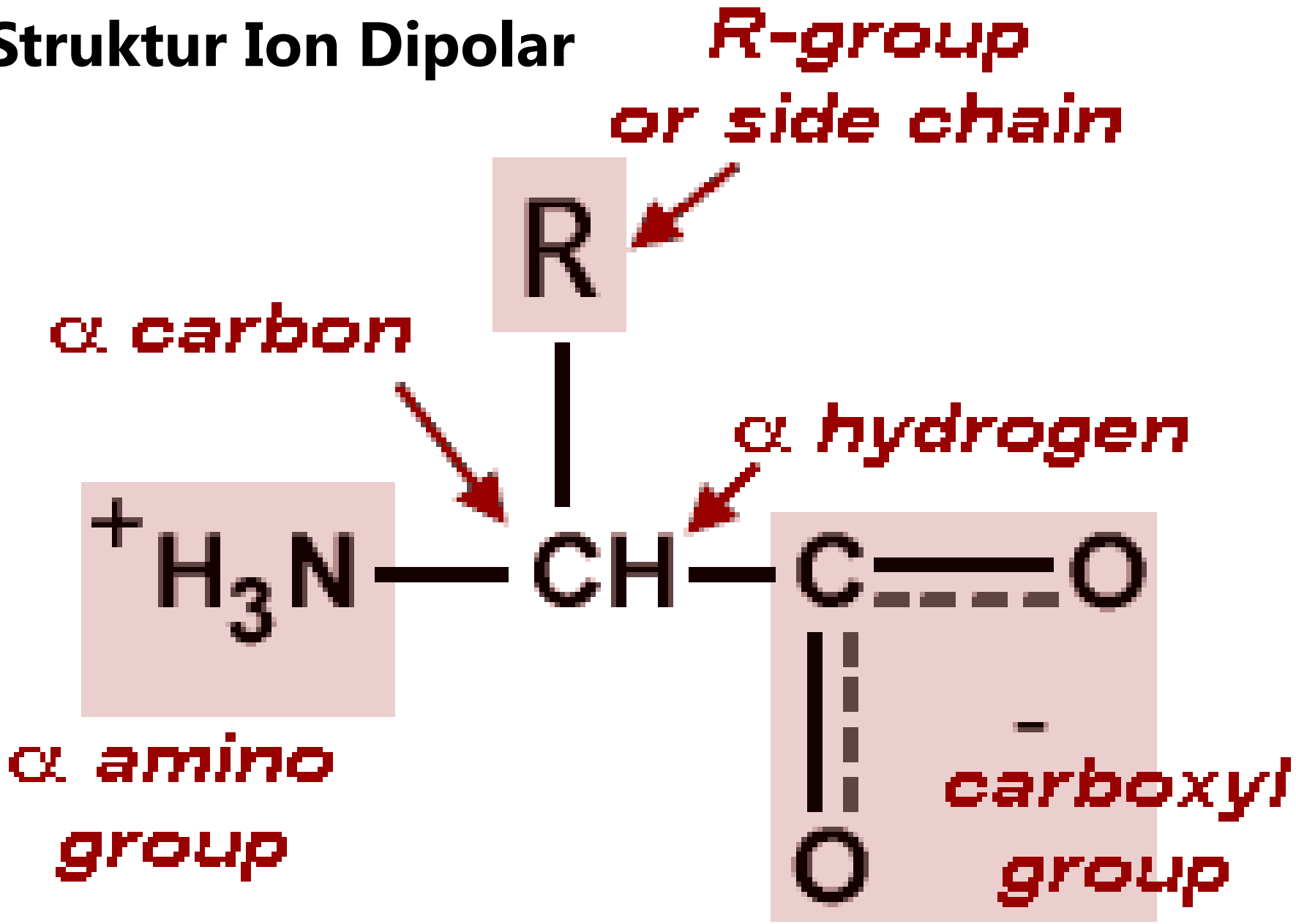
- Terdapat 20 jenis asam amino, yang berbeda satu sama lain pada gugus R yang terikat pada α-karbon
- Gugus R dapat bersifat gugus alifatik non-polar, gugus alifatik polar, gugus aromatik, dan bermuatan positif/negatif.
- Asam amino yang paling sederhana: glisin (gugus R adalah H)



- α-C bersifat asimetrik (mengingat gugus yang berbeda, yaitu –COOH, -NH_2, H dan R
- Kecuali pada Glisin, R-nya adalah H

A theoretical amino acid

Struktur Ion Dipolar



Kelompok Asam amino Berdasarkan Sifat Kepolaran

Non-polar, R gugus alifatik

- Gugus R tersusun dari gugus hidrokarbon yang bersifat hidrofobik.
- Glisin, alanin, valin, leusin, metionin, isoleusin

R gugus aromatik

- Gugus R tersusun dari struktur cincin aromatik atau sulfur
- Fenilalanin, tirosin, triptofan

Polar, gugus R tidak bermuatan

- Gugus R mengandung gugus hidroksil atau gugus amino
- Bersifat hidrofilik (dapat membentuk ikatan hidrogen)
- Serin, treonin, sistein, prolin, asparagin, glutamin

Kelompok Asam amino Berdasarkan Sifat Kepolaran

R bermuatan positif

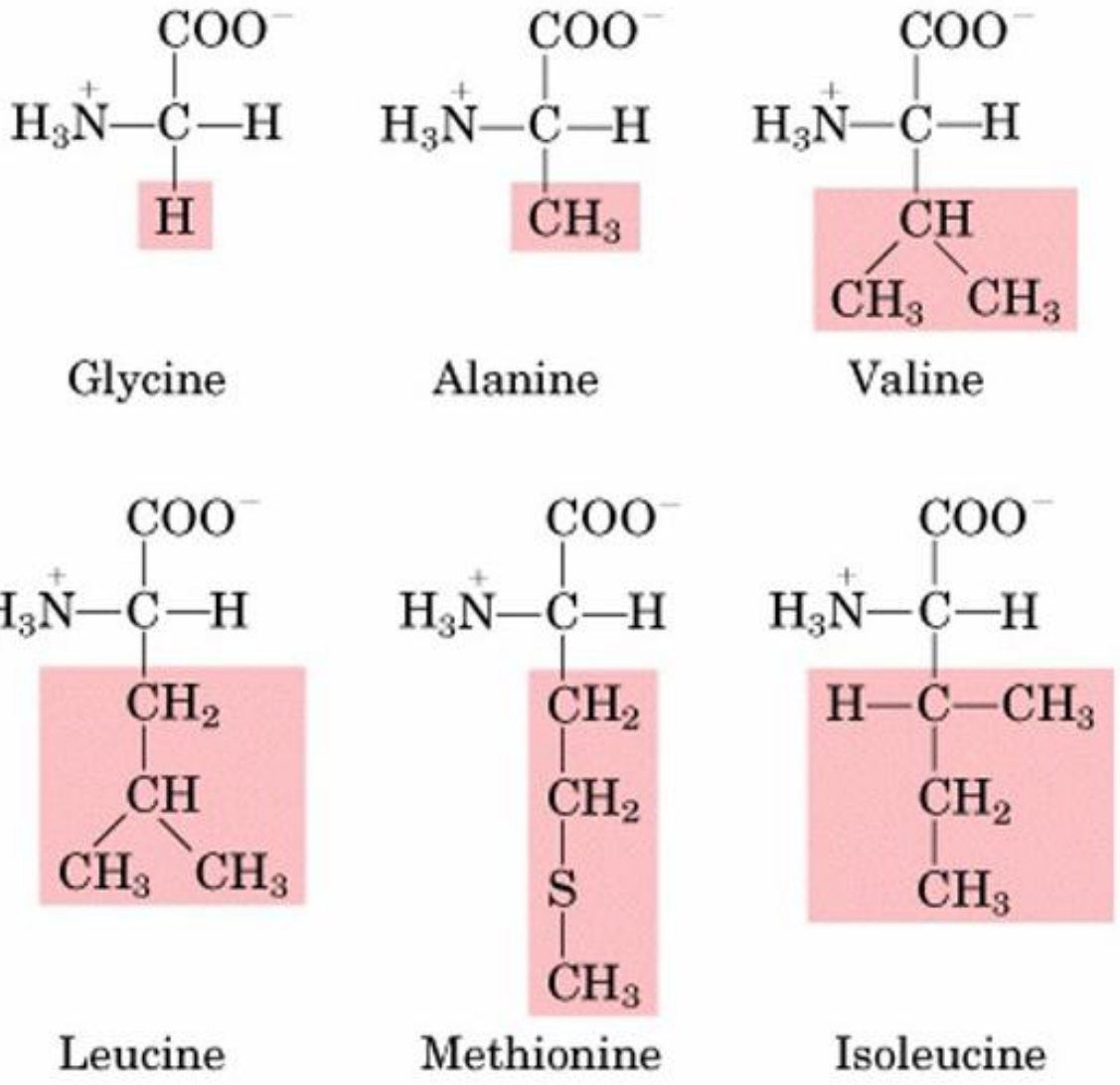
- Gugus R mempunyai gugus amide yang dapat membentuk ion positif pada pH di bawah 7.0
- Lisin, arginin, histidin

R bermuatan negatif

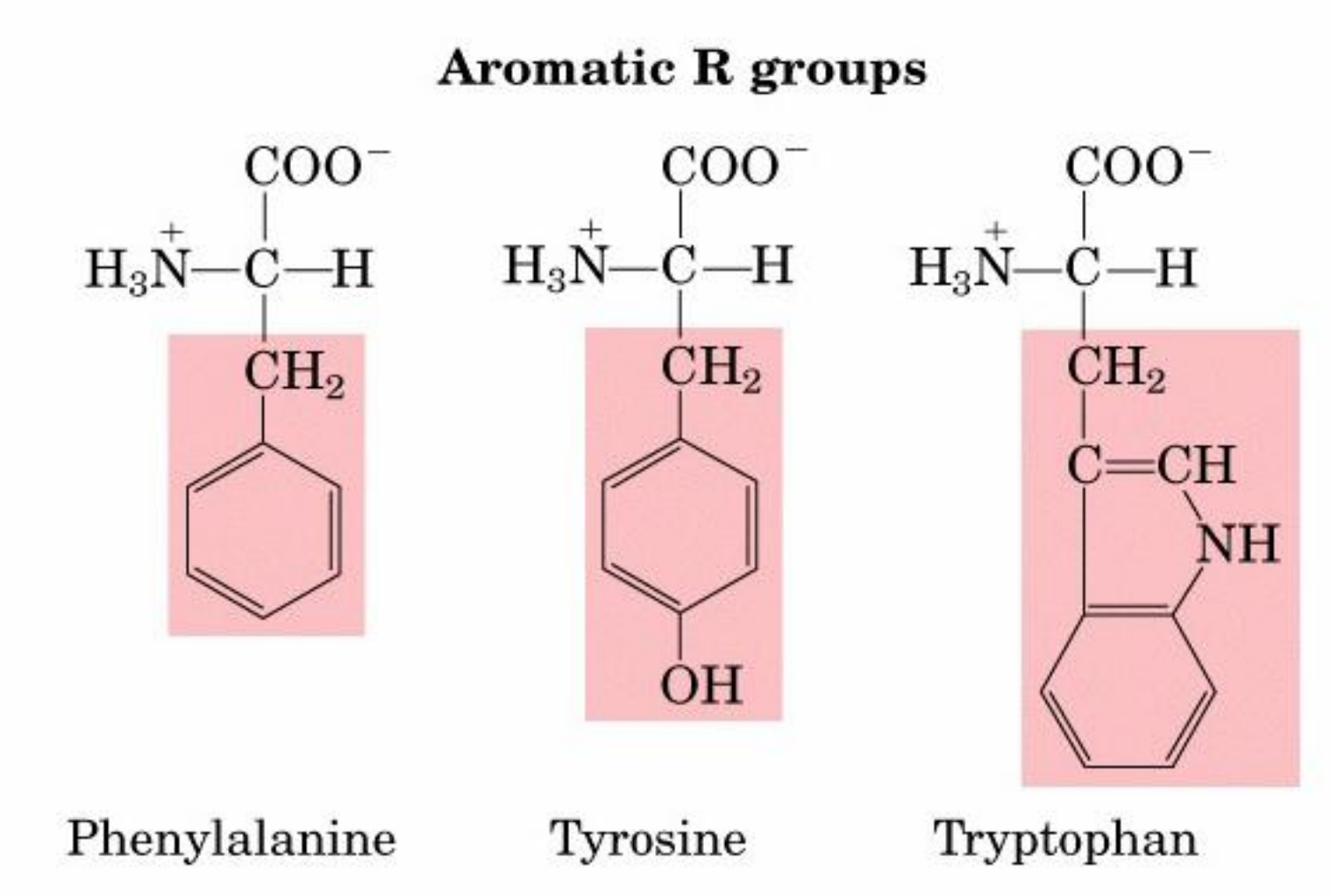
- Gugus R mempunyai gugus COOH yang dapat membentuk ion negatif pada pH di atas 7.0
- Asam aspartat, Asam glutamat

Twenty standard Amino Acids

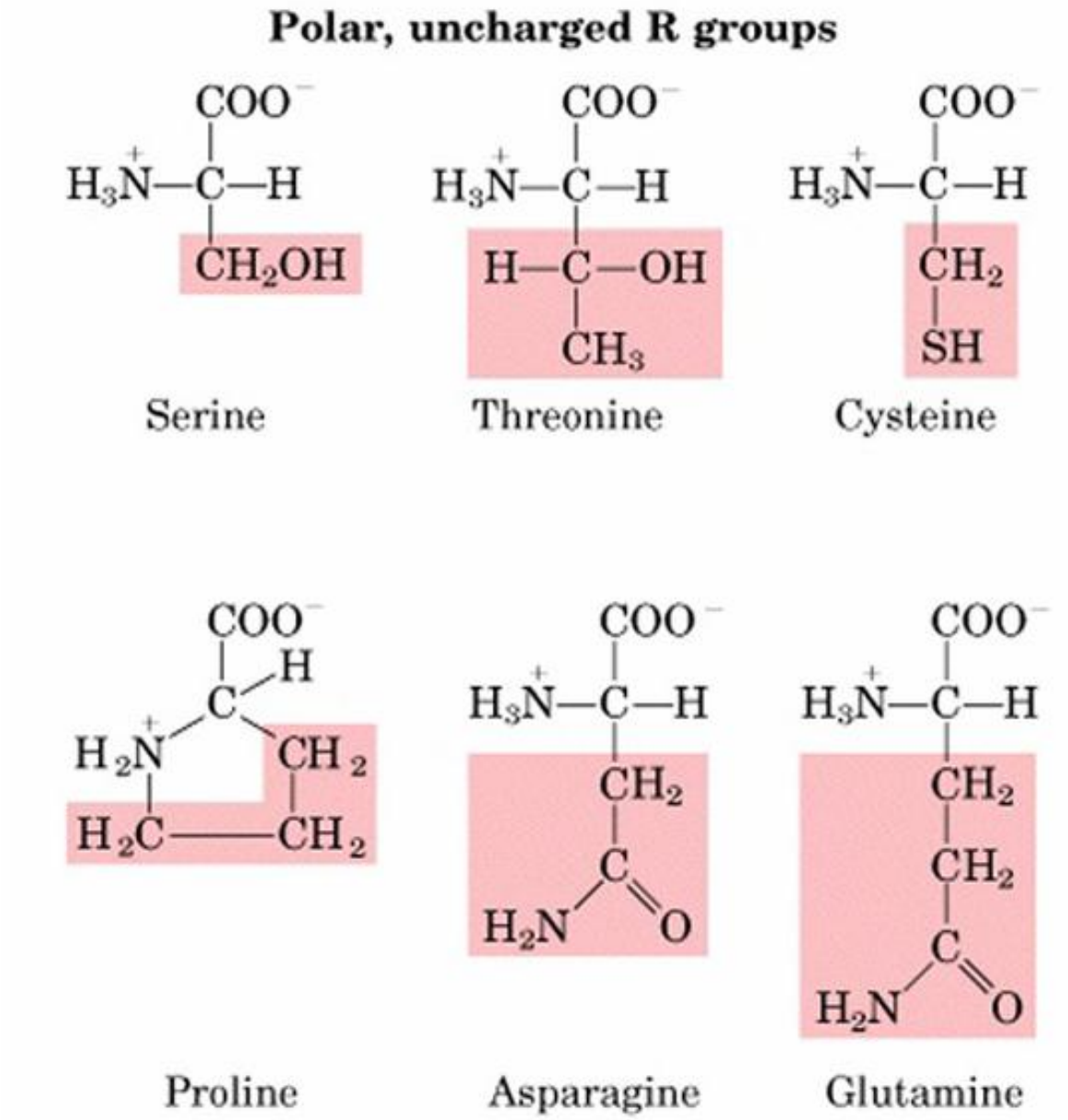
Nonpolar, aliphatic R groups



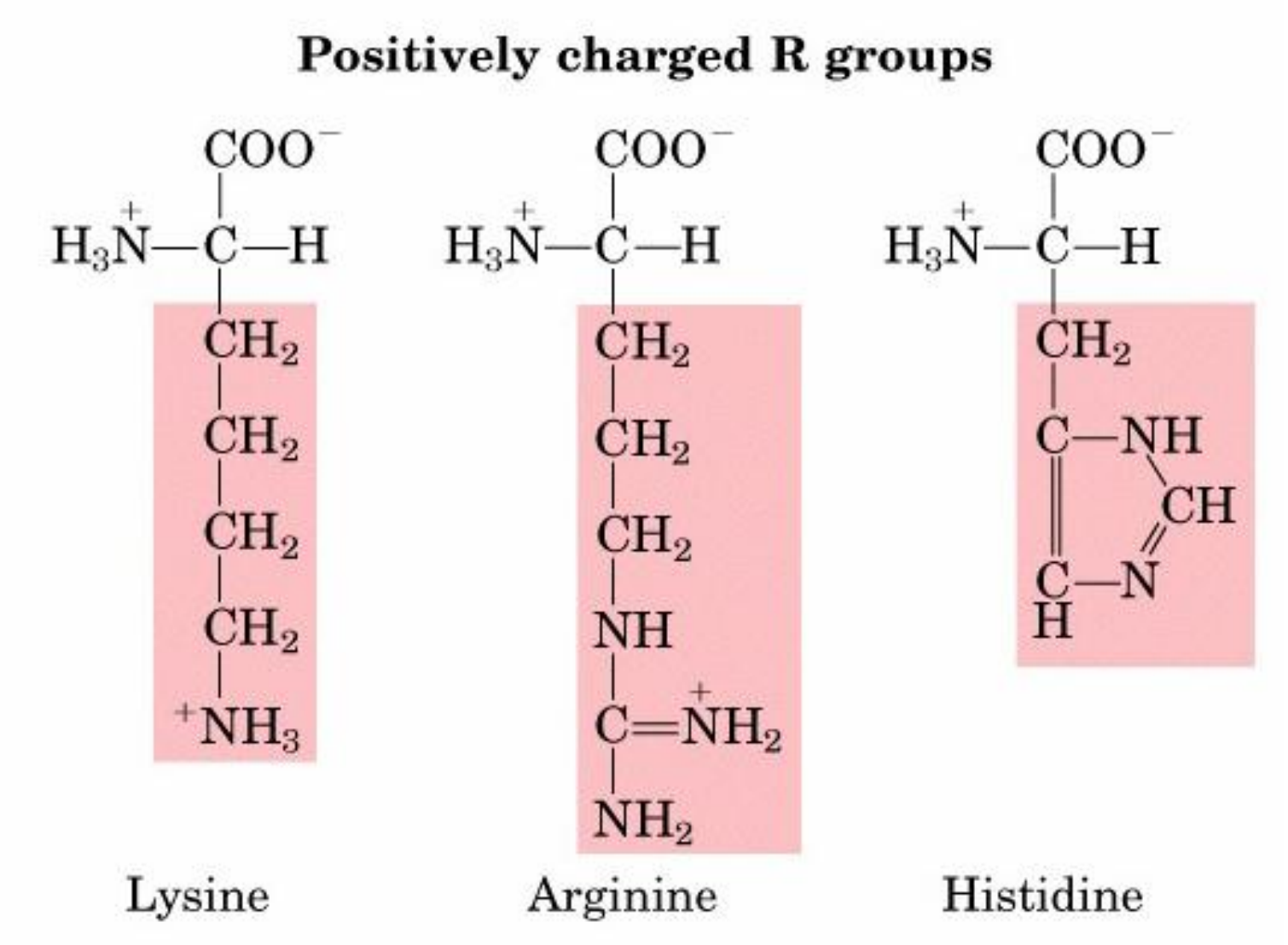
Twenty standard Amino Acids



Twenty standard Amino Acids

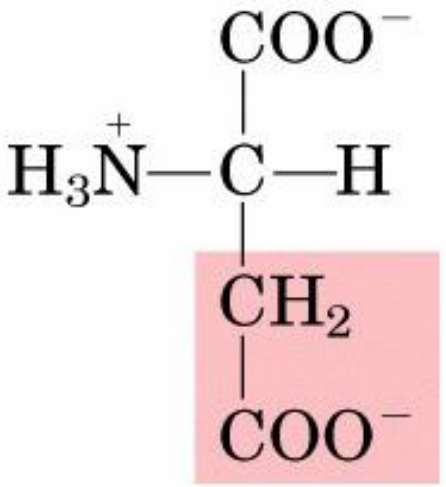


Twenty standard Amino Acids

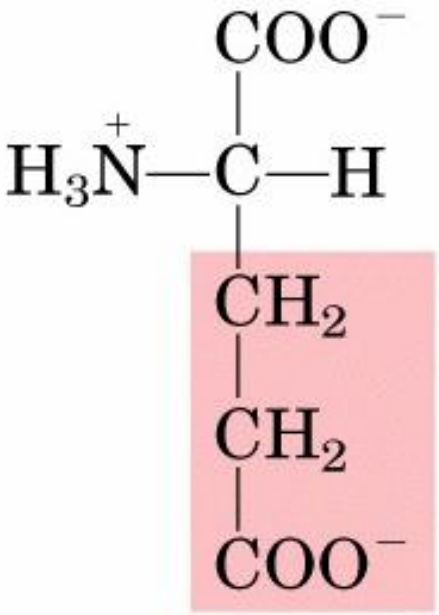


Twenty standard Amino Acids

Negatively charged R groups

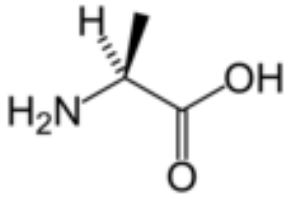
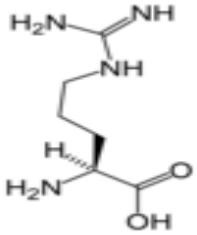
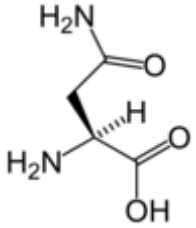
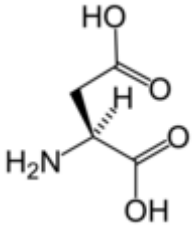
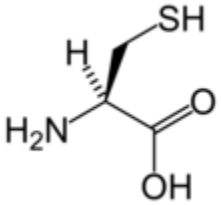
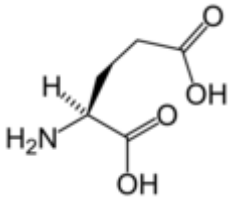
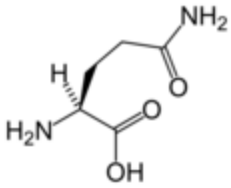
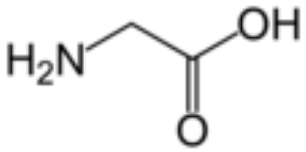
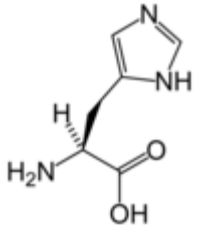
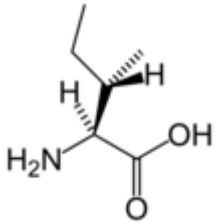
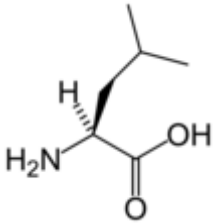
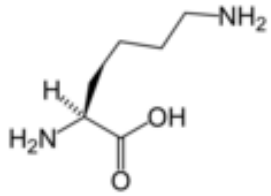


Aspartate

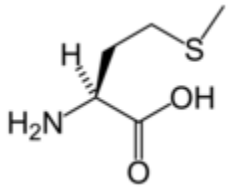
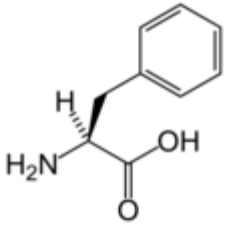
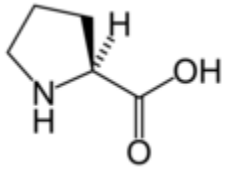
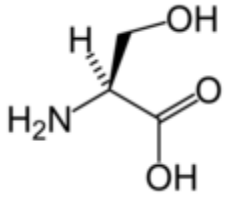
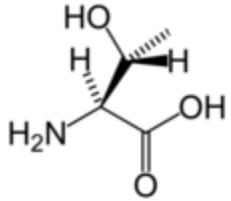
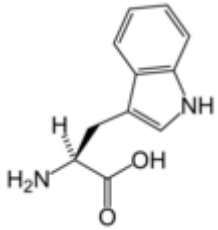
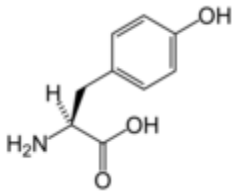
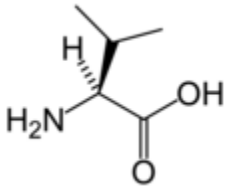


Glutamate

Struktur dan Singkatan 20 Asam Amino

 **L-Alanine (Ala / A)**	 **L-Arginine (Arg / R)**	 **L-Asparagine (Asn / N)**	 **L-Aspartic acid (Asp / D)**
 **L-Cysteine (Cys / C)**	 **L-Glutamic acid (Glu / E)**	 **L-Glutamine (Gln / Q)**	 **Glycine (Gly / G)**
 **L-Histidine (His / H)**	 **L-Isoleucine (Ile / I)**	 **L-Leucine (Leu / L)**	 **L-Lysine (Lys / K)**

Struktur dan Singkatan 20 Asam Amino

 **L-Methionine (Met / M)**	 **L-Phenylalanin (Phe / F)**	 **L-Proline (Pro / P)**	 **L-Serine (Ser / S)**
 **L-Threonine (Thr / T)**	 **L-Tryptophan (Trp / W)**	 **L-Tyrosine (Tyr / Y)**	 **L-Valine (Val / V)**

Sifat ionisasi Asam amino

- Di dalam larutan, asam amino terionisasi dan dapat bersifat sebagai asam atau basa (bersifat amfoter).
- Dalam keadaan dipolar (zwitterion), dimana gugus amin dan karboksil berionisasi, asam amino memiliki kelarutan yang minimal.
- Titik isoelektrik: pH pada saat molekul asam amino tidak bermuatan
- pK: pH pada saat gugus amino dan karboksil 50% terionisasi dan 50% tidak terionisasi.

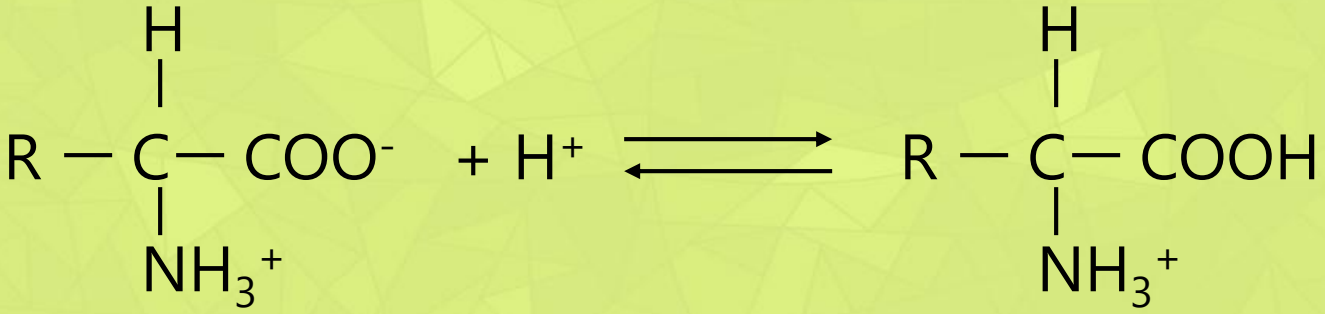
Titik Isoelektrik Asam Amino

Asam Amino	pI	Asam Amino	pI
Gly	6.0	Phe	5.5
Ala	6.0	Tyr	5.7
Val	6.0	Trp	5.9
Leu	6.0	Asp	3.0
Ile	6.0	Glu	3.2
Ser	5.7	Asn	5.4
Thr	5.6	Lys	9.7
Cys	5.0	Arg	10.8
Met	5.7	Gln	5.7
Pro	6.3	His	7.6

Electrical Charges

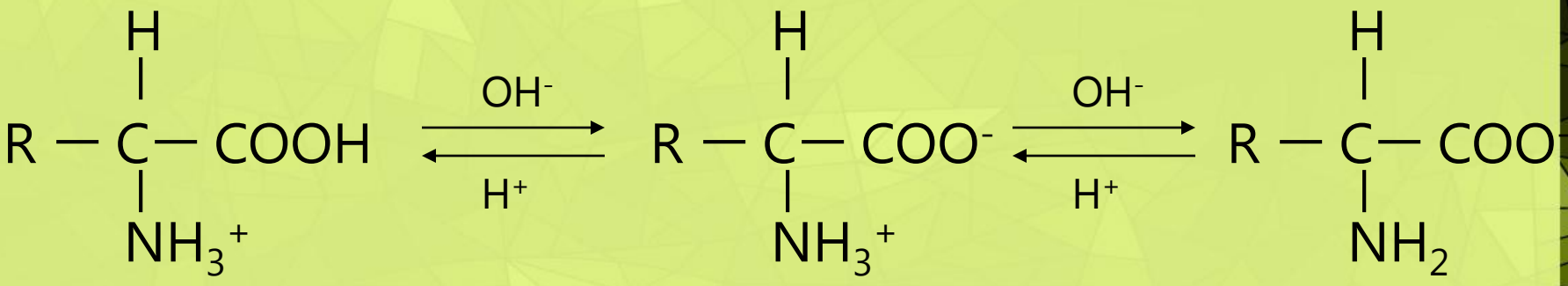
- Some individual amino acid residues in a protein have the potential to be charged electrically in different ways, depending on the pH of the medium in which the protein is found.
- The individual protein molecules are said to be **amphoteric,** because they have the potential to function as either acid or a base, depending on the pH.
- **Iso electric point:** when the number of positive and negative charges are equal. Protein has minimum solubility at the isoelectric point.

Ionisasi Asam Amino



(Zwitterion)

Ionisasi glisin pada berbagai nilai pH; Contoh



pH ~ 1 **pH ~ 6** **pH ~ 11**

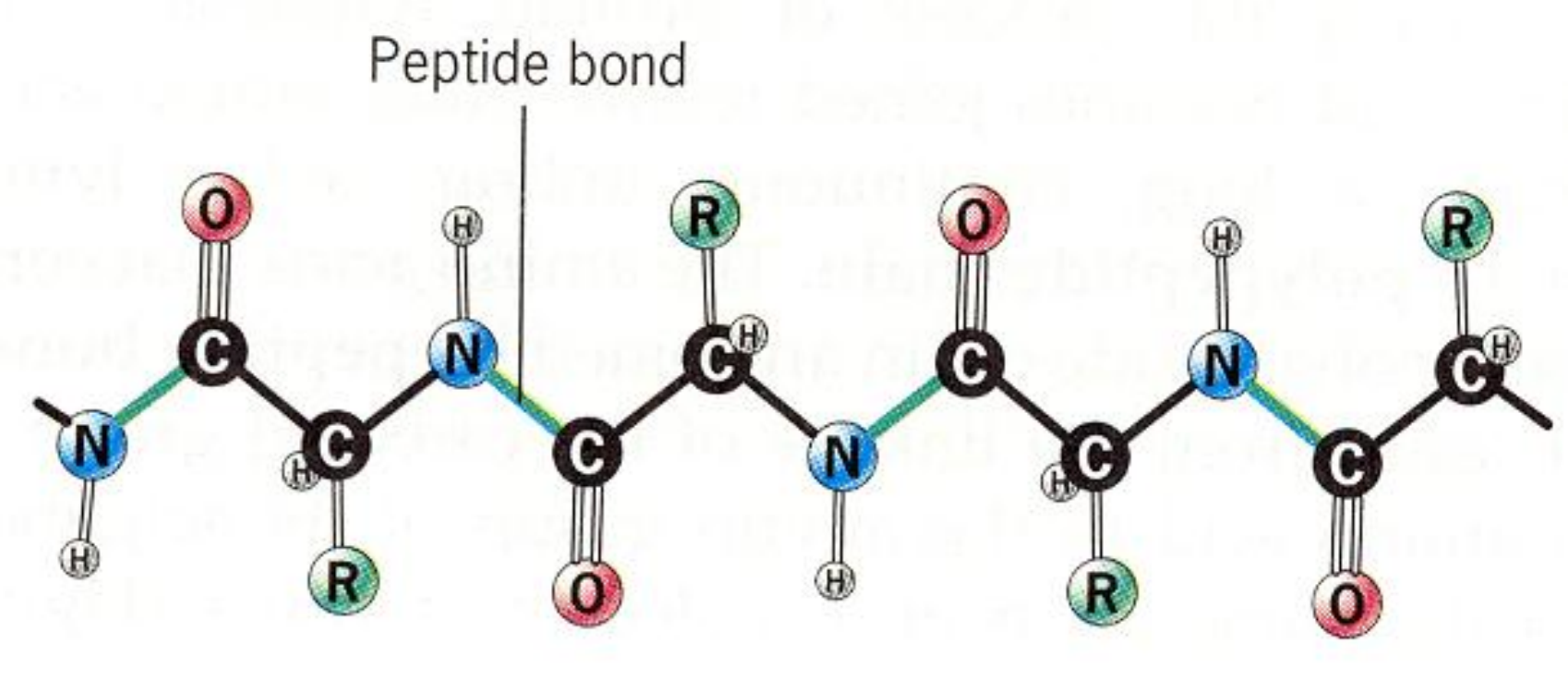
Polimerisasi

- Jenis polimerisasi:
  - Dipeptida: 2 asam amino berikatan
  - Oligopeptida:
  - Polipeptida:
  - Protein:
- Dihubungkan satu sama lain dengan ikatan peptida

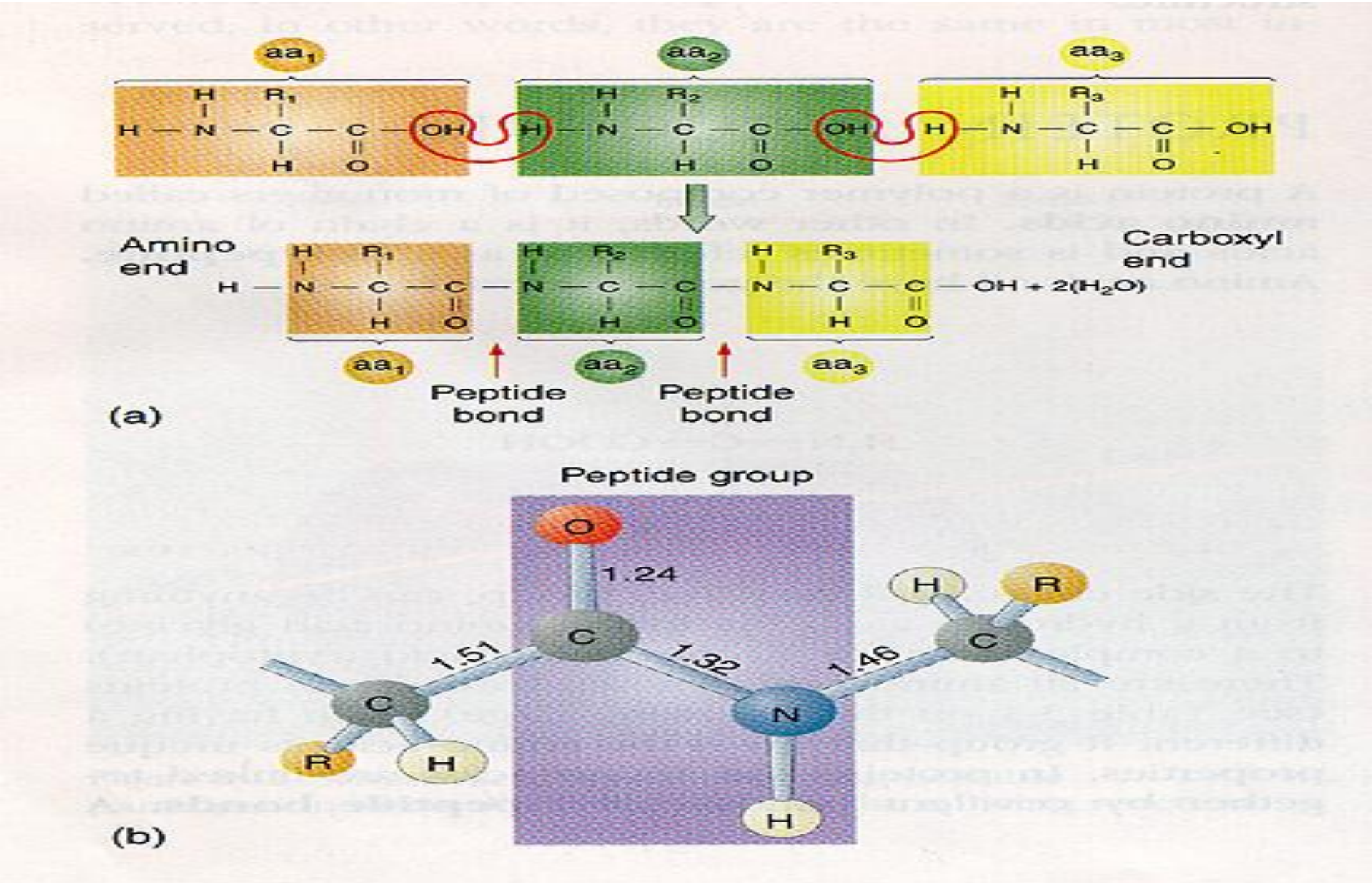
Ikatan peptida

- Ikatan peptida merupakan ikatan kovalen yang menghubungkan antara gugus amin ($-NH_2$) pada AA1 dengan gugus karboksil (-COOH) pada AA2
- Pada saat terbentuk ikatan peptida, 1 molekul air dibebaskan (polimerisasi kondensasi)
- Ikatan peptida lebih pendek dan lebih kuat daripada ikatan C-C, tetapi lebih lemah dibanding C=C.
- Ikatan peptida tidak dapat berotasi secara bebas

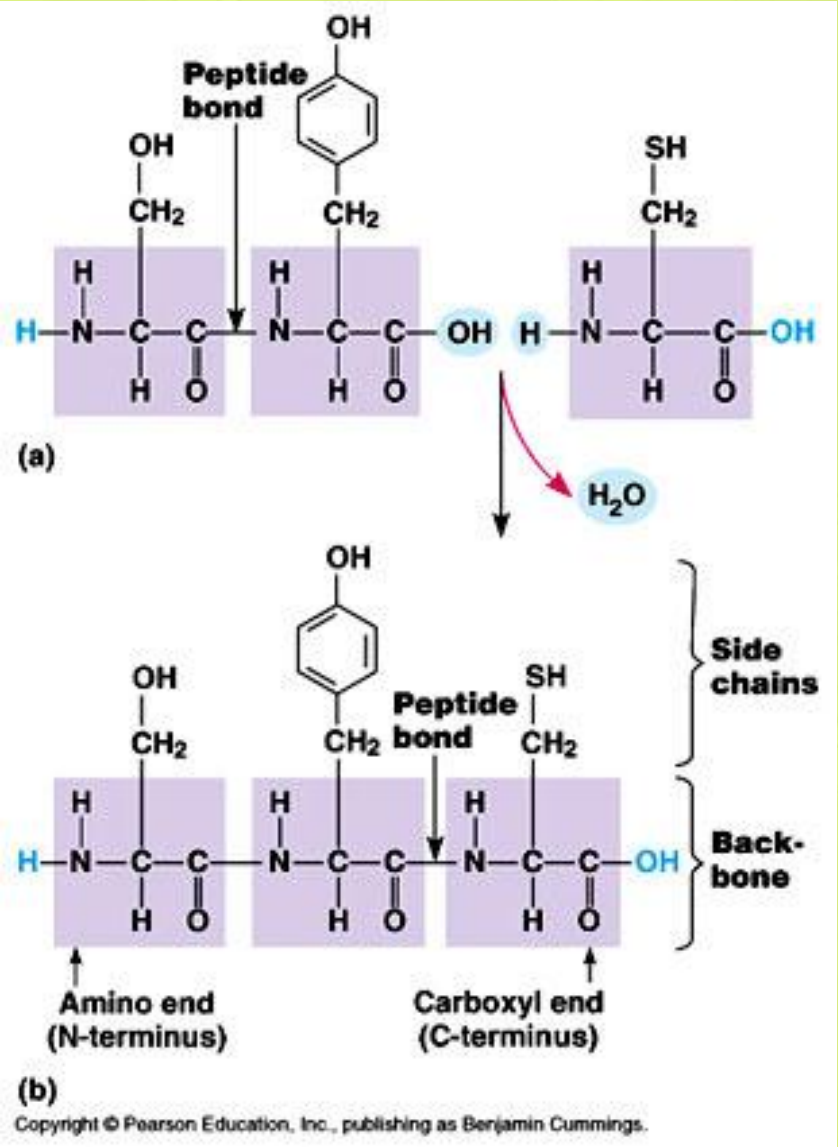
Ikatan peptida



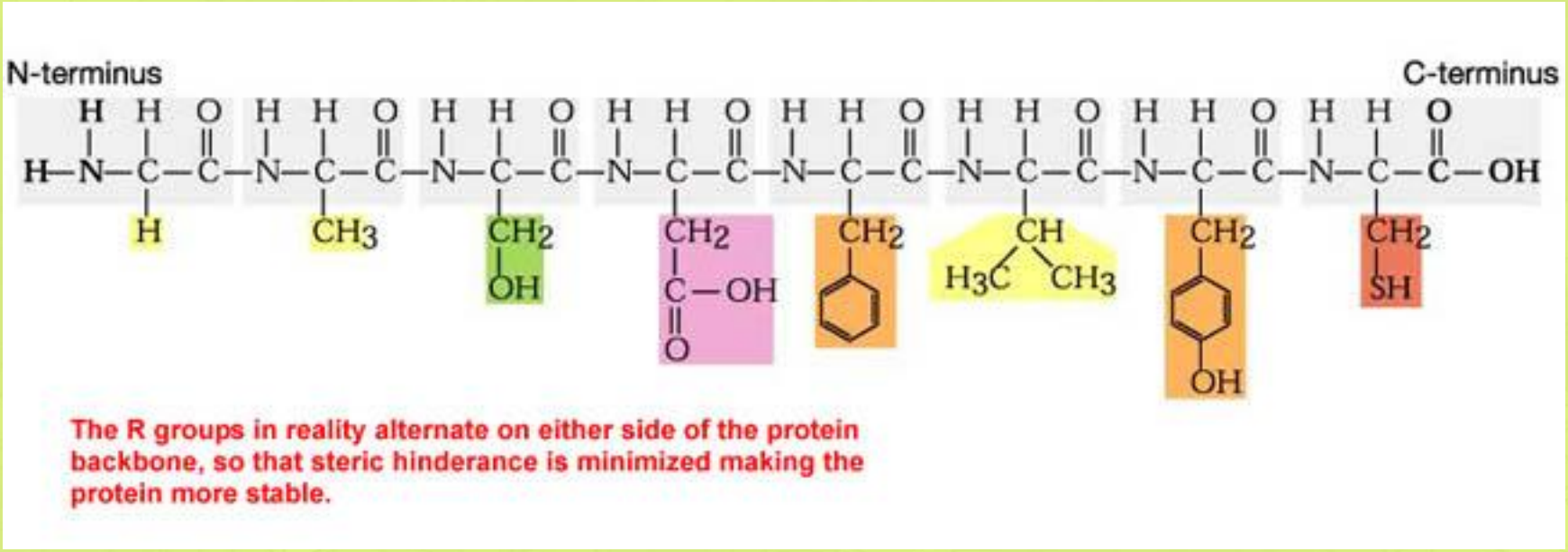
Pembentukan Ikatan Peptida Untuk membentuk struktur Protein/peptida



Reaksi Pembentukan Peptida



Struktur Peptida hasil polimerisasi



The R groups in reality alternate on either side of the protein backbone, so that steric hinderance is minimized making the protein more stable.

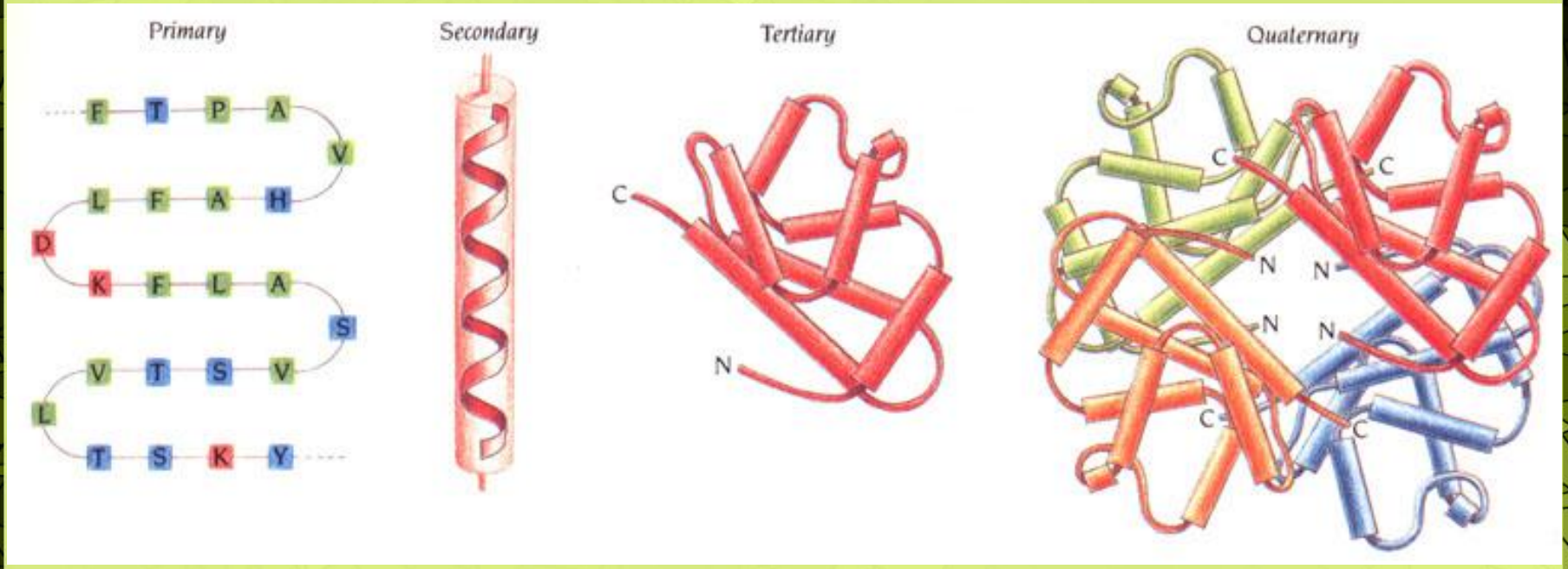
Bonds Between Protein Chain

Bond Type	Functional groups involved	Disrupting solvents
Electrostatic: $-COO^{-}{}^{+}NH_3^{-}$	Carboxyl Amino	Salt solutions High or low pH
Hydrogen bond -(C=O)NH HO-	Hydroxyl, Amide, Phenol	Urea solutions
Hydrophobic bonds	Long aliphatic chain, aromatic	Detergents, organic solvents
Disulfide bonds -S-S-	Cystine	Reducing agents, sulfite, marcapto-ethanol

Protein Structure

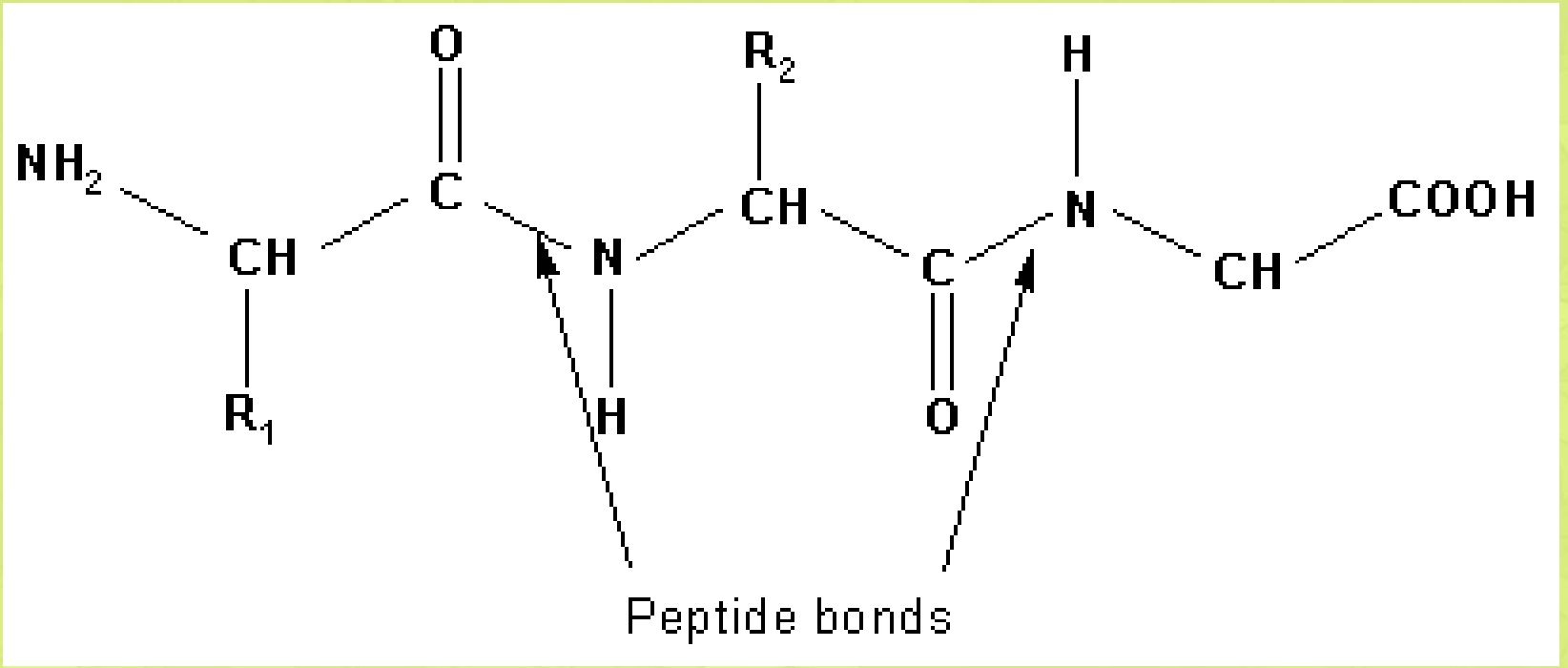
Primary sequence	Linear sequence of AA's from N-terminal to C-terminal NCC-NCC-NCC-NCC-NCC-NCC-NCC-NCC
Secondary structure	Regular, recurring orientations of AA's in a peptide chain due to H-bonds = alpha helix & beta sheets
Tertiary	• 3D - conformational shape due to weak electrostatic interactions with other atoms • Shape of most proteins is GLOBULAR
Quaternary	2 or more different polypeptides or sub-units interacting to give a unique 3D spatial relationship

Protein Structure

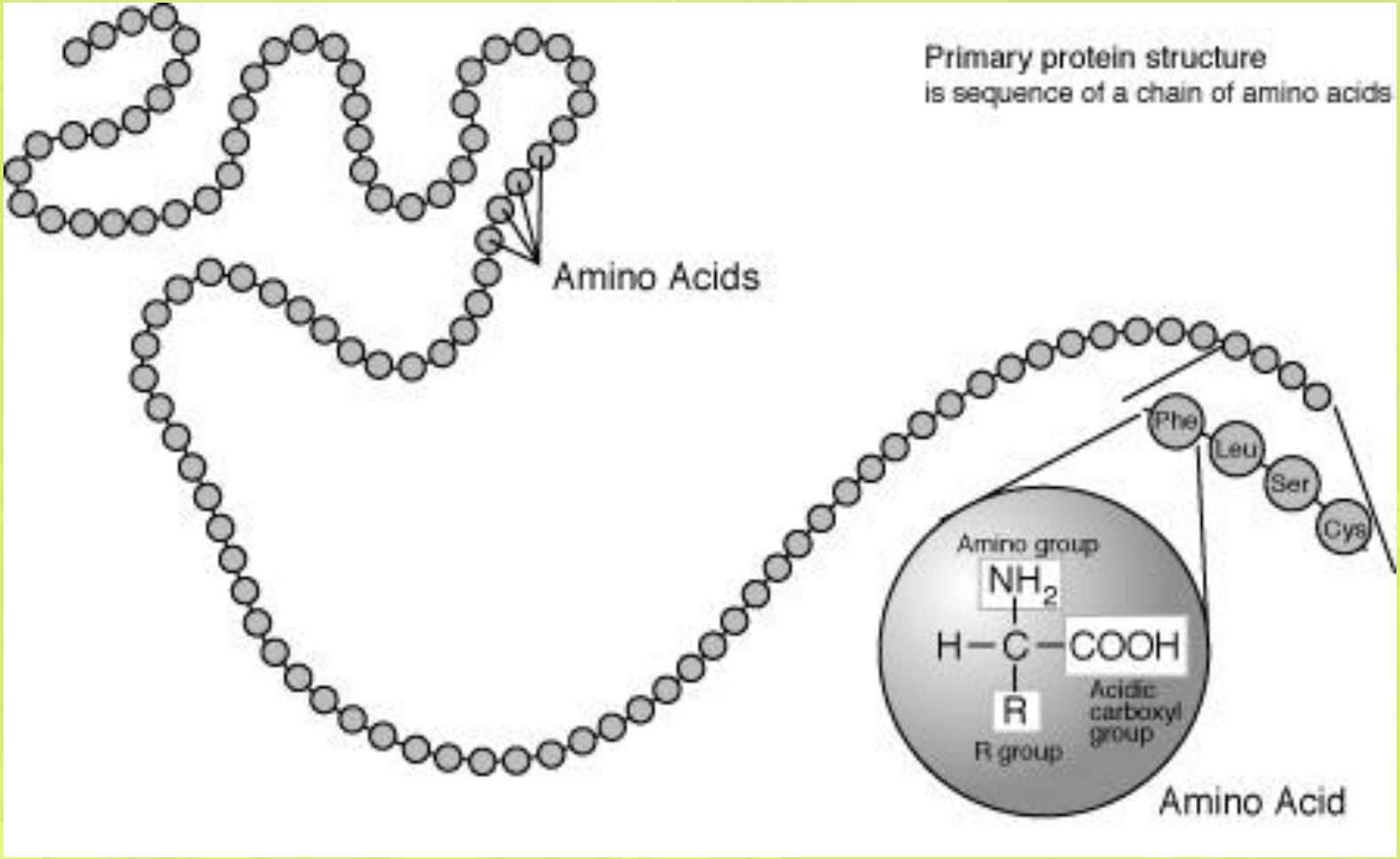


Struktur Protein

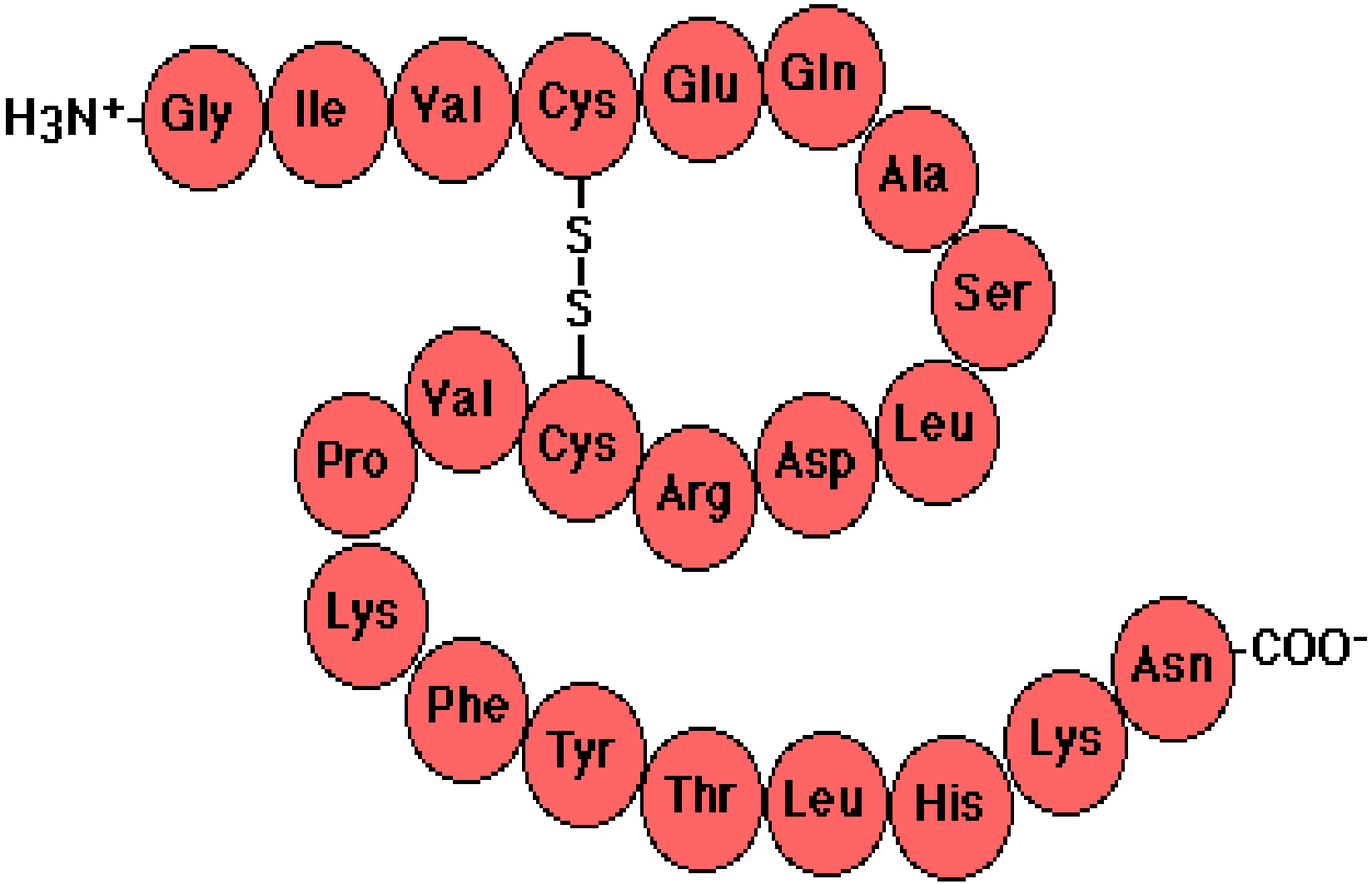
- Struktur primer (ikatan peptida)



Struktur Protein

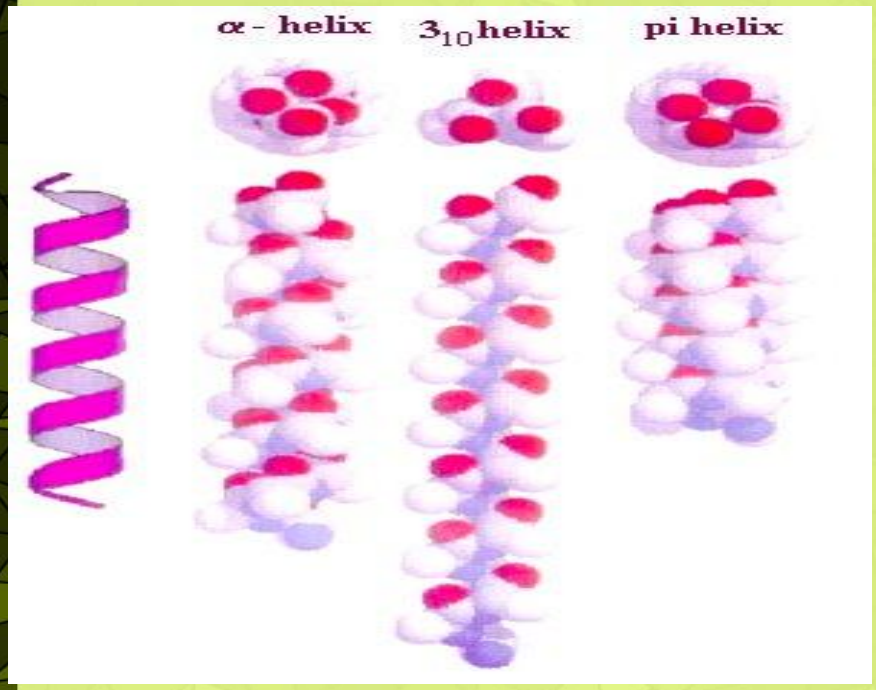


Struktur Primer

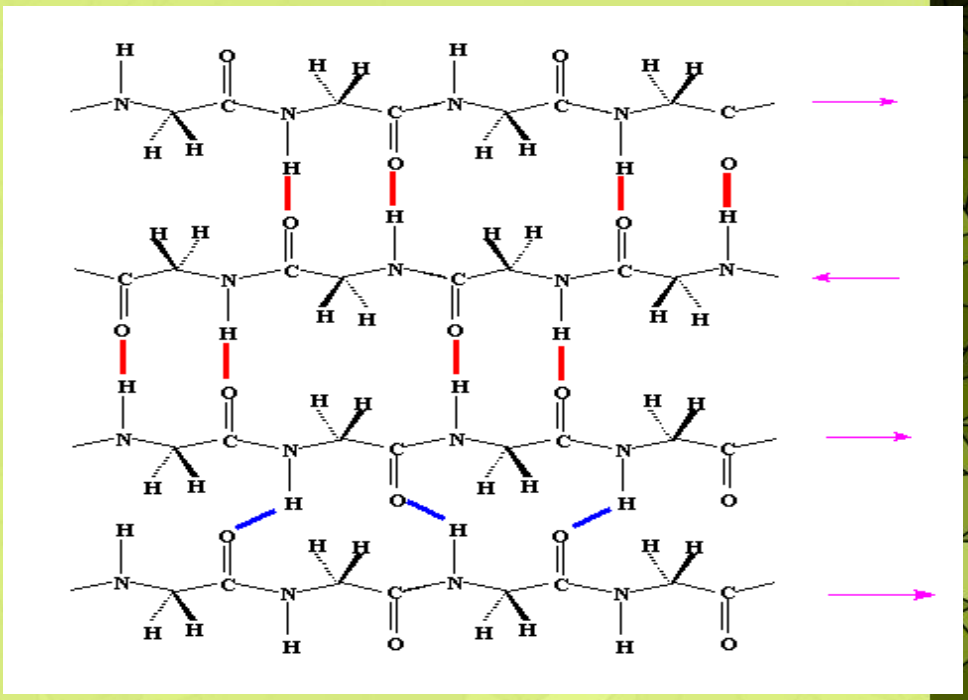


Struktur Protein

- Struktur sekunder (ikatan hidrogen)



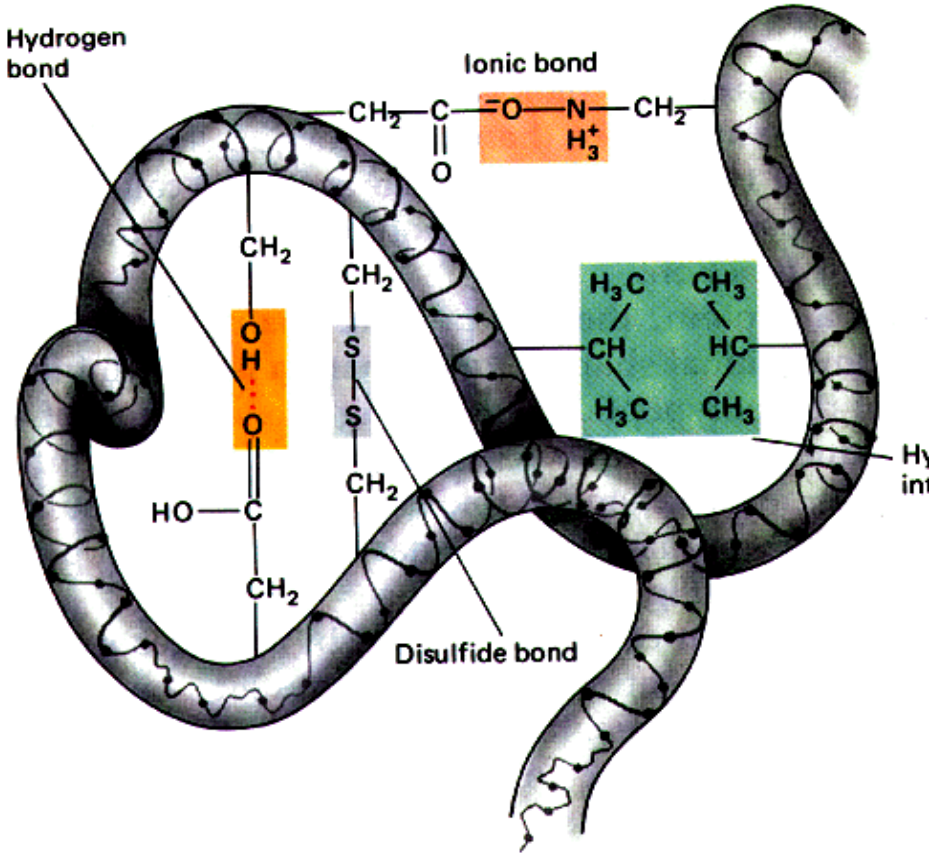
α-heliks protein



β-sheet protein sutera

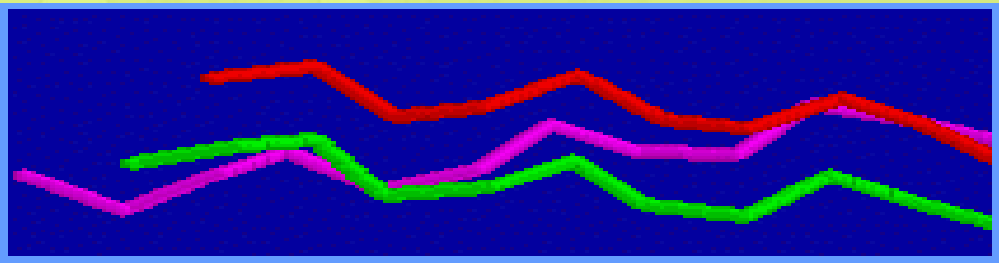
Struktur Protein

- Struktur tersier (disebabkan adanya ikatan hidrogen, ikatan garam, interaksi hidrofobik, dan ikatan disulfida)

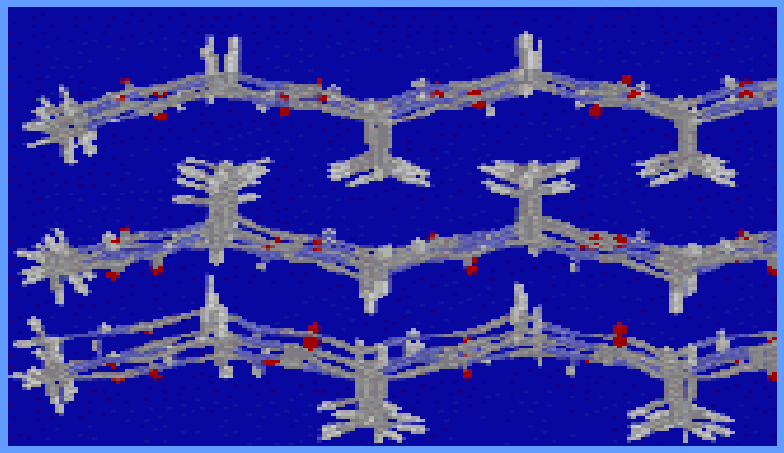


Struktur Protein

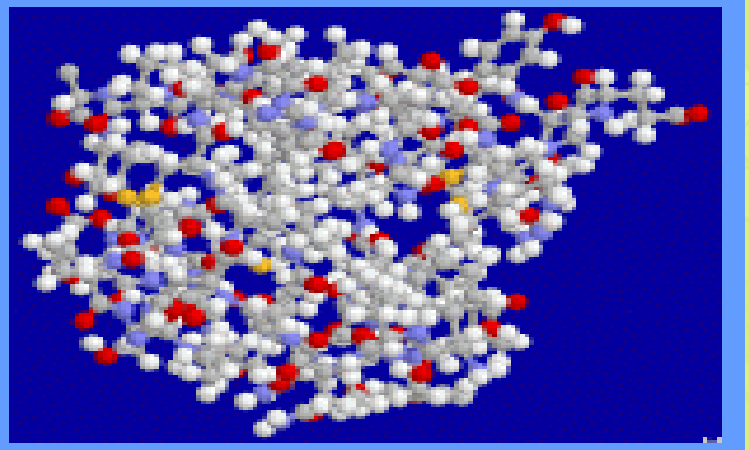
- Struktur kuartener (agregat beberapa unit protein/ terdiri dari beberapa rantai polipeptida)



Collagen

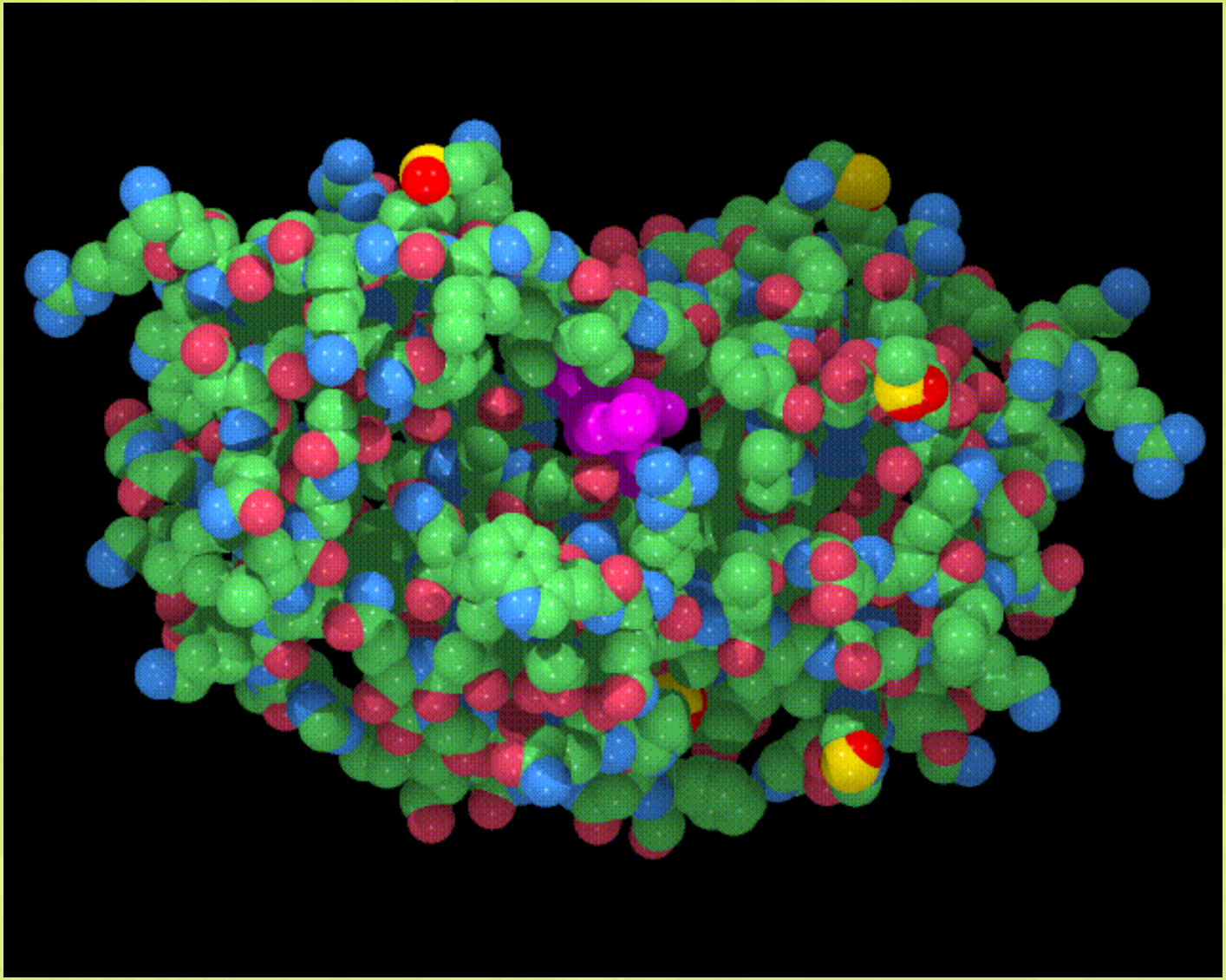


Silk



Insulin

Struktur Kuartener



Types of Protein

- ***Globular protein:*** native proteins that are rather spherical in the configuration of their tertiary structure. Exp. Albumin (egg), globulin (meat, legume), histone (glandular tissue), protamines (fish sperm cells)
- ***Fibrous protein:*** Insoluble, elongated protein molecules. Exp. Collagen, elastin (in meats, poultry)
- ***Conjugated protein:*** proteins combined with some other type of compound, such as a carbohydrate or lipid. Exp: mucoproteins (glycoproteins), lipoprotein, metalloprotein, nucleoprotein, phosphoprotein

Example of Food Protein in Structures and shapes

Food Proteins	Protein Structure	Protein shape
Egg albumin	Globular	Spherical
Meat and legume globulins	Globular	Spherical
Collagen	Fibrous	Elongated
Elastin	Fibrous	Elongated
Glycoprotein: ovomuvoid	Conjugated	Protein bound to carbohydrate and hemagglutinin
Lipoprotein: chylomicron	Conjugated	Protein bound to lipid LDL and VLDL
Metalloprotein: hemoglobin	Conjugated	Protein bound to metal ferritin and myoglobin
Phosphoprotein: casein	Conjugated	Protein bound to phosphorus

Komponen Bahan Pangan	Perubahan Yang mungkin Terjadi selama Proses Pengolahan dan Penyimpanan Pangan
Protein	• **Denaturasi (karena panas)** yang akan menyebabkan perubahan kelarutan, sehingga mempengaruhi tekstur pada bahan pangan • Penyimpangan flavor yang disebabkan karena **oksidasi (dikatalisis oleh cahaya)** • **Degradasi enzimatik** yang akan menyebabkan perubahan pada tekstur dan flavor (bisa menyebabkan terbentuknya flavor pahit) • **Pembekuan** dapat menyebabkan protein mengalami perubahan konformasi dan kelarutannya

Protein Denaturation

- Denaturation of proteins involves the disruption and possible destruction of both the secondary and tertiary structures.
- Since denaturation reactions are not strong enough to break the peptide bonds, the primary structure (sequence of amino acids) remains the same after a denaturation process.
- Denaturation disrupts the normal alpha-helix and beta sheets in a protein and uncoils it into a random shape.

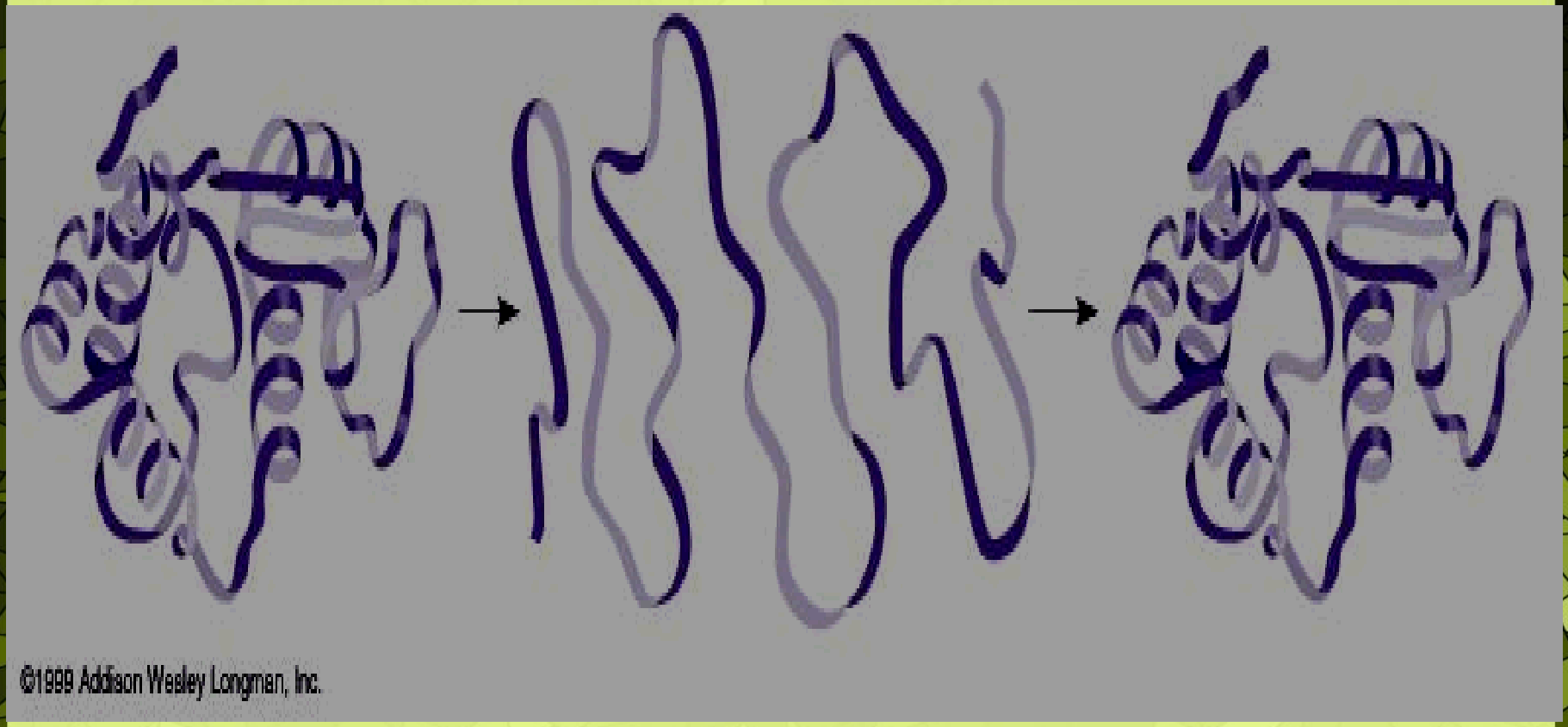
Protein Denaturation

- Denaturation occurs because the bonding interactions responsible for the secondary structure (hydrogen bonds to amides) and tertiary structure are disrupted.
- In tertiary structure there are four types of bonding interactions between "side chains" including: hydrogen bonding, salt bridges, disulfide bonds, and non-polar hydrophobic interactions, which may be disrupted. Therefore, a variety of reagents and conditions can cause denaturation.
- The most common observation in the denaturation process is the precipitation or coagulation of the protein.

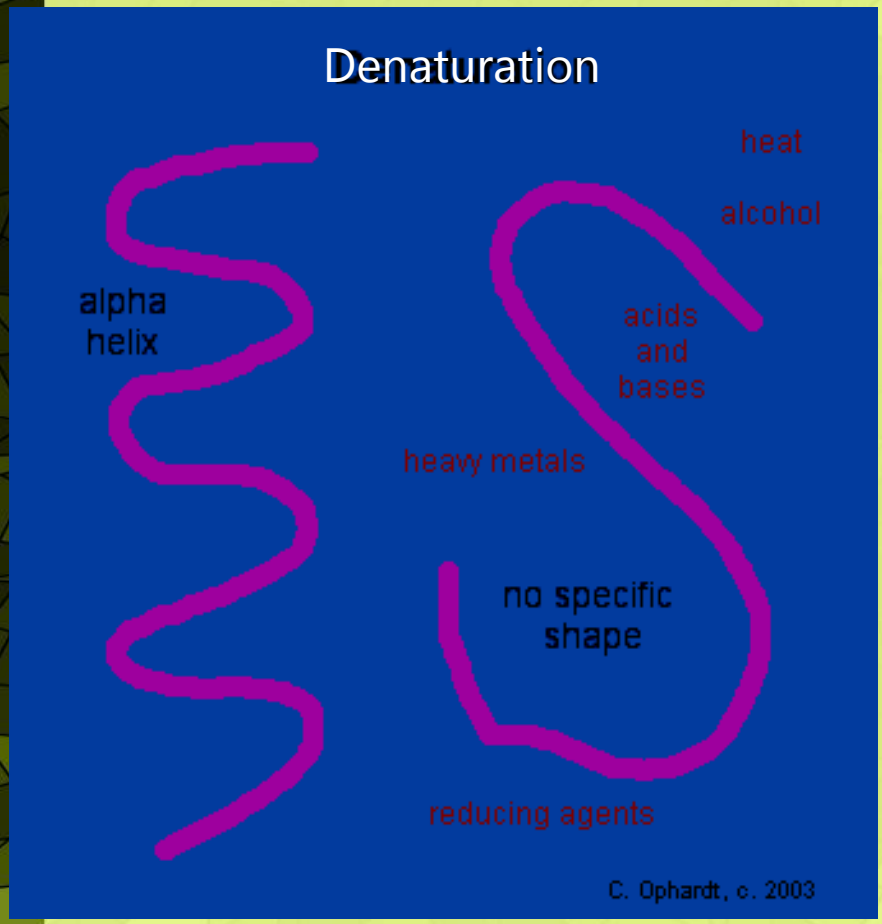
Protein Denaturation

- Unfolding of protein structure (due to H bonds breaking) without disrupting protein covalent bonds.
- Functional properties of protein will change during denaturation (e.g. enzyme function will be stopped; solubility in water will decrease).
- Example:
  - Thermal processing denatures the meat protein actin, myosin and myoglobin.
  - Cooking egg denatures egg white proteins including ovalbumin

Protein Denaturation



Factors Influencing Protein Denaturation



- Heat
- Alcohol
- Acid or Base
- Heavy metals
- Reducing Agents

Protein Denaturation

- **Effect of Alcohol**
  - Hydrogen bonding occurs between amide groups in the secondary protein structure. Hydrogen bonding between "side chains" occurs in tertiary protein structure in a variety of amino acid combinations. All of these are disrupted by the addition of another alcohol.
  - Alcohol denatures proteins by disrupting the side chain intramolecular hydrogen bonding. New hydrogen bonds are formed instead between the new alcohol molecule and the protein side chains.

Protein Denaturation

- **Effect of Acids and Bases**
  - **Salt bridges** result from the neutralization of an acid and amine on side chains.
  - The final interaction is ionic between the positive ammonium group and the negative acid group.
  - Any combination of the various acidic or amine amino acid side chains will have this effect.

Protein Denaturation

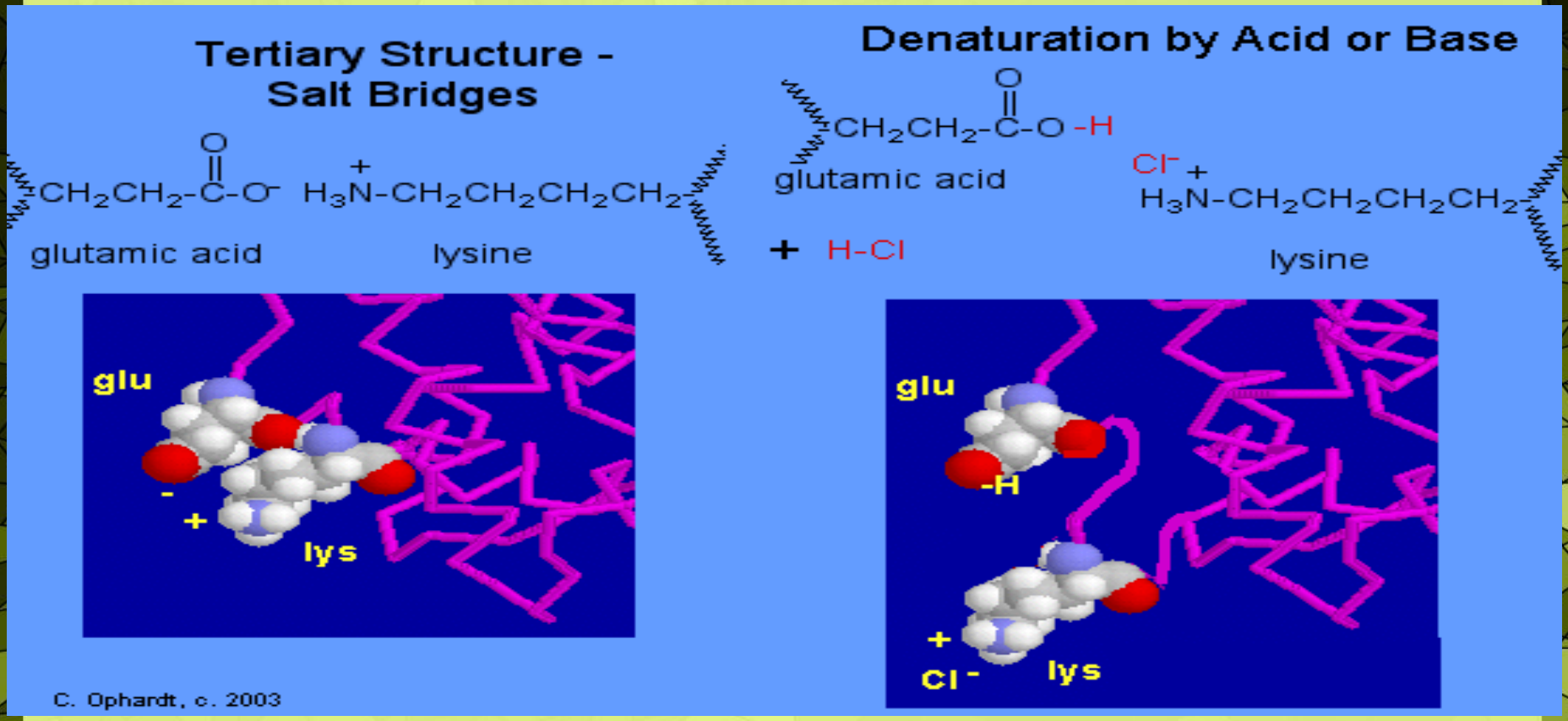
- **Effect of Acids and Bases**
  - Acids and bases disrupt salt bridges held together by ionic charges. A type of double replacement reaction occurs where the positive and negative ions in the salt change partners with the positive and negative ions in the new acid or base added.
  - This reaction occurs in the digestive system, when the acidic gastric juices cause the curdling (coagulating) of milk.

Protein Denaturation

- **Effect of Acids and Bases**
  - The denaturation reaction on the salt bridge by the addition of an acid results in a further straightening effect on the protein chain

Denaturasi

- Perubahan struktur sekunder, tersier dan kuartener protein
- Perubahan konformasi protein
- Struktur primer tetap → protein tidak terfragmentasi



Denaturasi

Flour → Process → Bread